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(54) Layshaft change-speed gear unit with concentric input shafts drivable through double clutch

(57) A spur change-speed gear unit is provided which can be shifted under load by means of a double clutch assembly composed of two clutches (A, B) capable of anti-phase actuation under load, these clutches being connected on their output sides to respective ones of two concentrically arranged driving shafts (2, 3), an output shaft (4) coaxial with the driving shafts (2, 3), two lay shafts (5, 6) parallel to, but offset from, the driving shafts, a plurality of gear trains (I to IV) including first and second gear trains (I, II) directly driven from respective ones of the driving shafts (3, 2), and a number of further clutches (C to J) selectively engageable in various different combinations to provide for various forward gear settings. In at least one possible gear setting, both lay shafts and/or components of the first and second gear trains are simultaneously operative. Thus, the structual complexity and length of the transmission mechanism are minimized. The unit preferably also includes a reverse gear assembly (54, 55) providing at least two reverse gears.

FIG.1

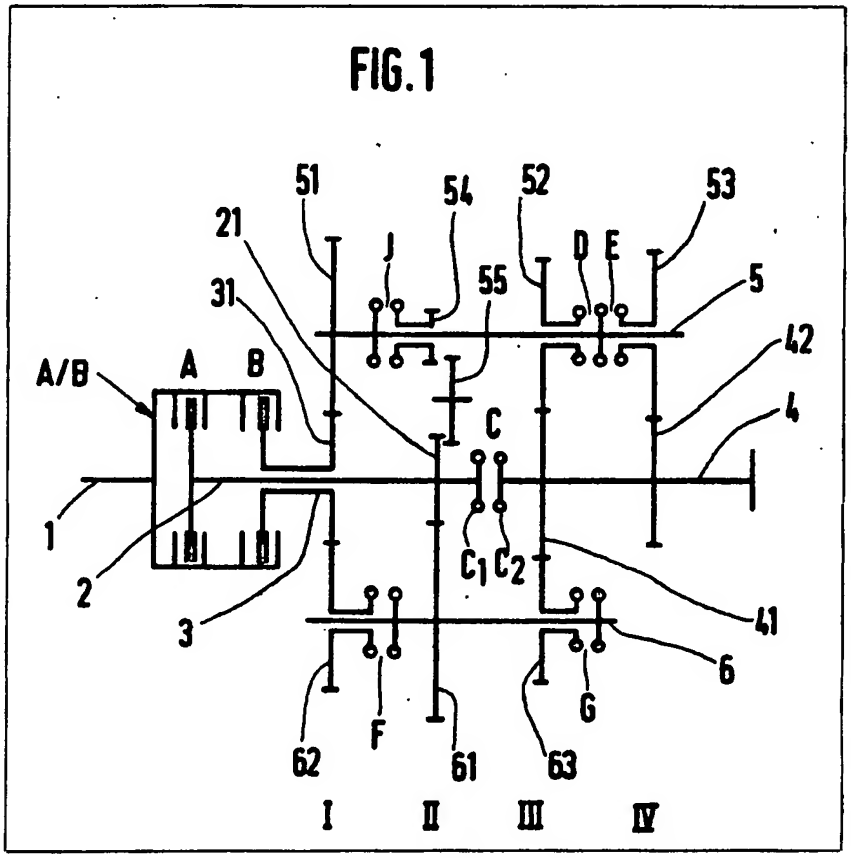

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FIG.1

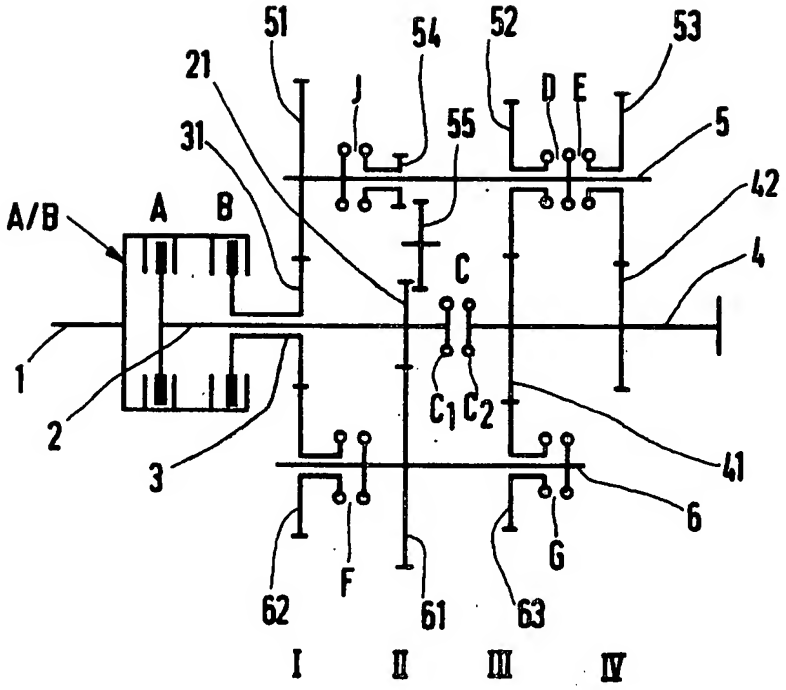

FIG.2

	i	A	B	C	D	E	F	G	J
R.2	3,0		o					o	o
R.1	4,0	o				o			o
1.G	4,4	o				o	o		
2.G	3,05		o			o			
3.G	2,1	o						o	
4.G	1,45		o		o				
5.G	1,0	o		o					
6.G	0,7		o	o			o		

FIG.3

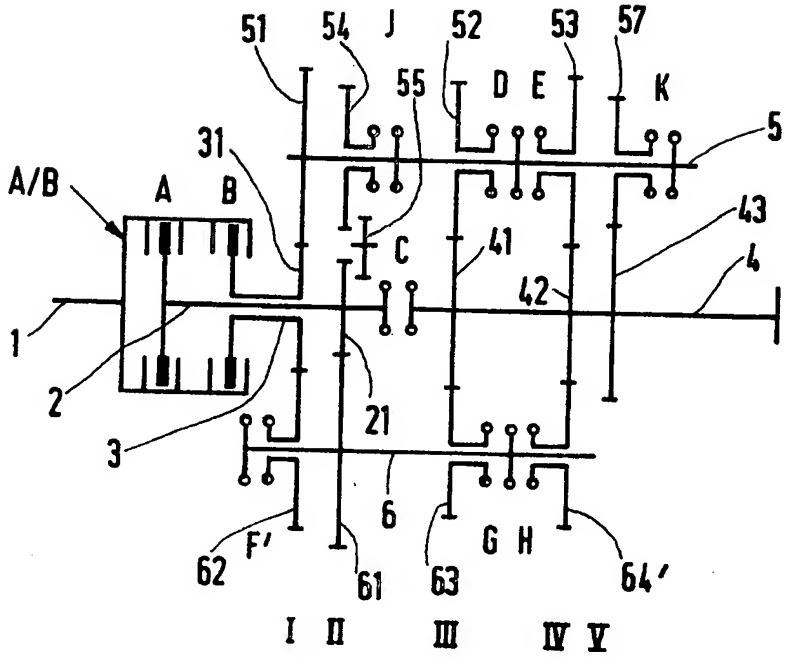

FIG.4

	i	A	B	C	D	E	F'	G	H	J	K
R.2	4,4		o					o		o	
R.1	6,0	o								o	o
1.G	9,1	o					o				o
2.G	6,41		o								o
3.G	4,42	o						o			
4.G	3,05		o		o						
5.G	2,10	o							o		
6.G	1,45		o			o					
7.G	1,0	o		o							
8.G	0,7		o	o			o				

FIG.5

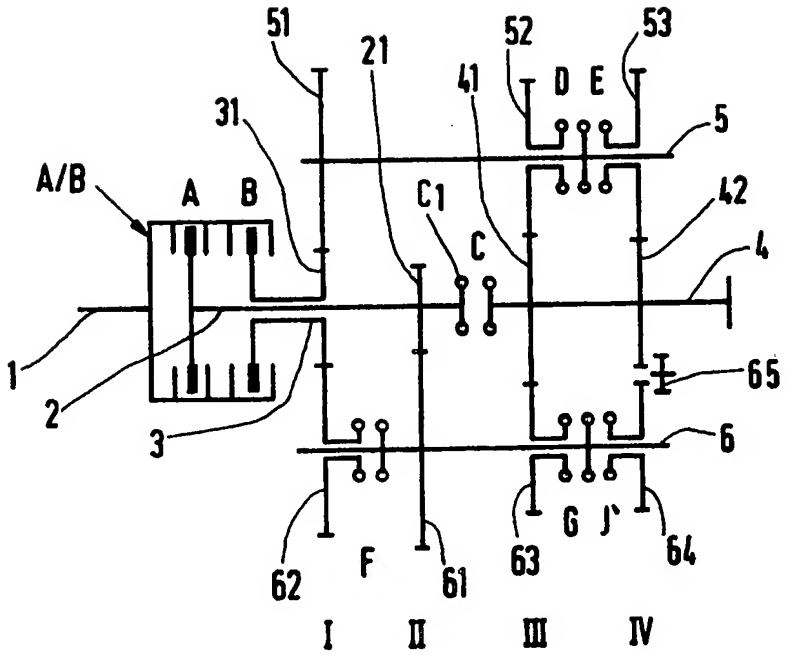

FIG.6

	i	A	B	C	D	E	F	G	J'
R.2	2,5		o				o		o
R.1	4,0	o							o
1.G	4,40	o				o	o		
2.G	3,05		o			o			
3.G	2,1	o						o	
4.G	1,45		o		o				
5.G	1,0	o		o					
6.G	0,7		o	o			o		

FIG.7

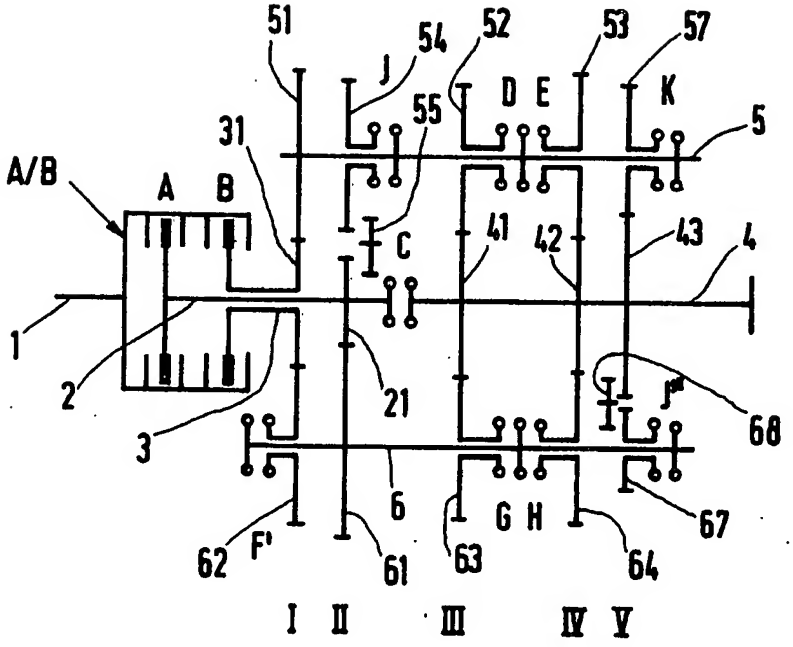

FIG.8

	i	A	B	C	D	E	F'	G	H	J	J"	K
R.3	2,6		o				o				o	
R.2	4,4		o					o		o		
R.1	6,0	o								o		o
1.G	9,1	o					o					o
2.G	6,41		o									o
3.G	4,42	o						o				
4.G	3,05		o		o							
5.G	2,10	o							o			
6.G	1,45		o			o						
7.G	1,0	o		o								
8.G	0,7		o	o			o					

FIG.9

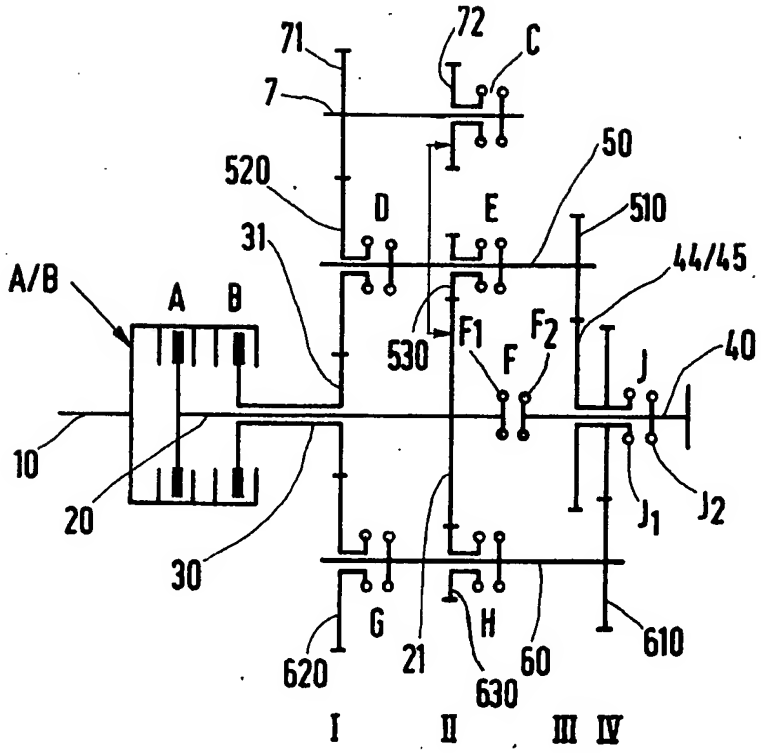

FIG.10

	i	A	B	C	D	E	F	G	H	J
R.2	3,05		o	o		o				
R.1	4,42	o		o				o		o
1.G	4,42	o							o	o
2.G	3,05		o					o		o
3.G	2,10	o				o				o
4.G	1,45		o		o					o
5.G	1,0	o					o			
6.G	0,70		o		o	o	o			

SPECIFICATION

Spur change-speed gear unit

This invention relates to a spur change-speed gear unit shiftable under load by means of a double clutch assembly. More particularly, the invention relates to gear units of the type comprising an input shaft, a double-clutch assembly formed by two first clutches which are capable of anti-phase actuation under load and are connected on their input sides to said input shaft and on their output sides respectively to a hollow driving shaft and a radially-inner driving shaft extending coaxially through said hollow shaft, a take-off shaft disposed in coaxial alignment with said driving shafts, two lay shafts disposed parallel to, but offset from, said driving shafts, a plurality of gear trains constituted by gear wheels carried on said shafts, and second clutches selectively engageable in different combinations to give various forward gear settings of the gear unit.

Such geat units are known, but up until now have hardly been used at all in automatic gear boxes for passenger and goods vehicles. This is not only due to the problems caused by the gear selection mechanism required, but also due to the relatively high constructional cost for the size of the gear unit concerned.

German patent specification DE-PS 883 691 describes a gear unit of the type under consideration where five foward gear ratios are achieved using, in addition to the first clutches of the double clutch assembly, four gear trains and six second clutches. The favourable positioning of the two lay shafts relative to the two concentrically arranged driving shafts and the coaxial take-off shaft result, as shown in Fig. 2 of the aforesaid specification, in a relatively favourable change-speed gear unit, which occupies little space. One disadvantage of this construction is that there is no reverse gear and if an intermediate wheel is added into one gear train (usually one near the gear unit take-off) in order to achieve a suitable reverse gear, this effictively reduces the unit to a four speed gear unit. A further disadvantge is that the space occupied by the gears is higher than need be due to the large number of second clutches and their associated control means. Furthermore, synchronizers are generally used in modern clutches which results in higher costs.

It is therefore the object of the present invention to provide a spur change-speed geat unit of the type specified above, which enables the constructional space required and cost involved (particularly in relation to the gear selection mechanism) to be reduced relative to the number of gear settings provided.

This object is achieved in accordance with the present invention by the provision of a spur change-speed gear unit of the aforesaid type, wherein the gear wheels and second clutches are arranged for multiple utilisation whereby to enable either additional useful forward and reverse gear settings to be obtained, or for the same number of gear settings, a reduction in the constructional complexity and therefore of the axial length of the gear unit.

According to another aspect of the present invention, there is provided a spur change-speed gear unit shiftable under load and comprising an input shaft, a double-clutch assembly formed by two first clutches which are capable of anti-phase actuation under load and are connected on their input sides to said input shaft and on their output sides respectively to a hollow driving shaft and a radially-inner driving shaft extending coaxially through said hollow shaft, a take-off shaft disposed in coaxial alignment with said driving shafts, first and second lay shafts disposed parallel, to but offset from, said driving shafts, a plurality of gear trains including a first gear train for transmitting drive between the hollow driving shaft and the first lay shaft and a second gear train for transmitting drive between the radially inner driving shaft and the second lay shaft, and second clutches selectively engageable in different combinations to give various gear settings of the gear unit, the arrangement of the gear unit being such that in at least one possible gear setting of the unit both lay shafts and/or components of both the first and second gear trains are simultaneously operative whereby to maximise utilisation of the gear unit components.

In the aforesaid German specification DE-PS 883 691 the first and second gear trains are utilised in different gear settings (for example, in the second and fourth gears, and in the first and third gears respectively) and only one lay shaft is operative at any one time (except, of course, in the straight through drive setting in which neither lay shaft is operative). In contrast, gear units of the invention as set out in the previous paragraph are so arranged that both lay shafts and/or components of both the first and secod gear trains are simultaneously used for torque transmission; as a result a considerably higher degree of utilisation of the gear unit components (gear wheels and second clutches) is achieved. In this way, either more gear settings can be provided for the same constructional effort or, of course, the same number of useful gears can be achieved for less effort.

In one preferred embodiment, the gear unit comprises four gear trains arranged as follows:

—the hollow driving shaft non-rotatably carries a driving gear wheel of the first gear train,

—the radially inner driving shaft ono-rotatably carries a drivng gear wheel of the second gear train and is selectively couplable by means of a said second clutch to said take-off shaft,

—the take off shaft non-rotatably carries a respective gear wheel from each of the third and fourth gear trains,

—said first lay shaft non-rotatably carries a gear wheel of the first gear train which is in mesh with the corresponding driving gear wheel carried on the hollow driving shaft, two further gear wheels respectively of the third and fourth gear trains being rotatably carried on the first lay shaft and meshing with the corresponding gear-train gear wheels on the take-off shaft, said further gear wheels being selectively couplable for rotation with the first lay shaft by respective second clutches,

—the second lay shaft non-rotatably mounts a gear wheel of the second gear train which is in mesh with the corresponding driving gear wheel carried on the radially inner driving shaft, a further gear wheel of the third gear train being rotatably carried on the second lay shaft and being in mesh with the gear wheel of the third gear train carried on the take-off shaft, said further gear wheel being selectively couplable for rotation with the second lay shaft by means of a said second clutch, the first gear train being arranged to selectively transmit drive between the hollow driving shaft and the second lay shaft by the provision of an auxiliary gear wheel rotatably carried on the second lay shaft and couplable for rotation therewith by means of a respective second clutch, the auxiliary gear wheel being in mesh with the driving wheel of the first gear train.

This embodiment of the gear unit can be provided with a reverse gear assembly comprising a reverse gear rotatably carried on the first lay shaft and selectively couplable for rotation therewith by means of a reverse-gear second clutch, and an intermediate gear wheel operatively interposed between the reverse gear wheel and the said driving gear wheel of the second gear train. Such an arrangement enables two reverse gear settings to be readily achieved and the positioning of the second clutch in the overall unit makes particularly good use of the space available.

The gear unit structure as set out in the last but one paragraph can conveniently be expanded to give further forward settings by providing the fourth gear train with an additional gear wheel carried on the second lay shaft and adding a fifth gear train between the first lay shaft and the take-off shaft. In this case, a reverse gear assembly can be provided, on the second lay shaft, which cooperates with the fifth gear train; at the same time, the unit can also be provided with a reverse gear assembly of the form set out in the previous paragraph in which case several reverse gear settings are possible which is advantageous in certain applications.

In another preferred embodiment, the gear unit comprises four gear trains arranged as follows:

—the hollow driving shaft non-rotatably carries a driving gear wheel of the first gear train,

—the radially-inner driving shaft non-rotatably carries a driving gear wheel of the second gear train and is selectively couplable for rotation with the take-off shaft by means of a said second clutch,

—the take-off shaft rotatably carries a respective gear wheel from the third and fourth gear trains, these gear wheels being fast for rotation with each other and being selectively couplable for rotation with the take-off shaft by means of a said clutch,

—the first lay shaft rotatably carries respective gear wheels from the first and second gear trains which gear wheels are in mesh with corresponding ones of the said driving gear wheels and are selectively couplable for rotation with the first lay shaft by means of respective second clutches, the first lay shaft further carrying a gear wheel of the third gear train which is fast for rotation with the first lay sahft and is in mesh with the third-train gear wheel carried on the take-off shaft, and

—the second lay shaft rotatably carries respective gear wheels from the first and second gear trains which gear wheels are in mesh with corresponding ones of said driving gear wheels and are selectively couplable for rotation with the second lay shaft by means of respective second clutches, the second lay shaft further carrying a gear wheel of the fourth gear train which is fast for rotation with the second lay shaft and is in mesh with the fourth train gear wheel carried on the take-off shaft.

This form of gear unit can be provided with a reverse gear assembly comprising a reverse gear shaft parallel to, but offset from, the driving shafts, a first reverse gear wheel fast for rotation with the reverse gear shaft and in mesh with the first-train gear wheel carried by the first lay shaft, and a second gear wheel which is rotatably carried by, but selectively couplable for rotation with, said reverse gear shaft and is in mesh with the driving gear wheel of the second gear train. Such an arrangement of the reverse gear assembly keeps down the axial length of the unit without significantly increasing its cross-sectional area as the reverse gear shaft can easily be placed between the two lay shafts. The overall gear unit has a favourable axial dimension due to the arrangement of the third and fourth gear trains.

In order to give an appropriate comparison of structural complexity of the prior art unit and

the embodiments of the invention described and illustrated hereinafter (see Figs. 1 to 10), the number of gear unit components—gear wheels, clutches operable under load, and ordinary clutches—are summed in the following Table and then divided by the number of usuable gears to give a value to the ratio: number of gear unit components/gear settings.

The Table contains two entries for the gear unit shown in the aforsaid German specification, the second of these entries being for the case where a reverse gear is provided by the addition of an intermediate gear wheel.

It is also to be noted that two values of the ratio (number of gear-unit components/gear settings) are calculated for each gear unit considered, one ratio value being for the case where all possible reverse gears are taken into account (Column 5), and the other ratio value being for the case where only one reverse gear is attributed to each unit (Column 8). In evaluating the Table it must be remembered that the constructional effort required for a clutch is much greater than for a gear wheel, not only in respect of the actual component itself, but also in respect of the gear unit control arrangement.

	1 load actuatable clutches	2 other clutches	3 gear wheels	4 total 1 to 3	5 gears	6 4:5	7 gears	8 4:7
DE-PS 883 691	2	6	10	18	5	3.6	5	3.6
DE-PS 893 691	2	6	10 + RG = 11	19	5	3.8	5	3.8
Fig. 5 + 6	2	6	12	20	8	2.5	7	2.9
Fig. 1 + 2	2	6	12	20	8	2.5	7	2.9
Fig. 3 + 4	2	8	15	25	10	2.5	9	2.8
Fig. 7 + 8	2	9	17	28	11	2.5	–	–
Fig. 9 + 10	2	7	12	21	8	2.6	7	3.0

Spur change speed gear units embodying the invention will now be particularly described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a gear diagram of a first gear unit embodying the invention, this unit being provided with four gear trains and a reverse gear assembly as well as with a double clutch assembly actuatable under load and various further clutches;

Figure 2 is a tabulation indicating for each gear setting of the Fig. 1 gear unit, both the clutches engaged and the corresponding overall transmission ratio through the unit;

Figure 3 is a gear diagram of a second gear unit embodying the invention, this unit being similar to that of Fig. 1, but including an additional gear train;

Figure 4 is a tabulation similar to that of Fig. 2 but for the gear unit of Fig. 3;

Figure 5 is a gear diagram of third gear unit embodying the invention, this unit being similar to that of Fig. 1 but including a different form of reverse gear assembly;

Figure 6 is a tabulation similar to that of Fig. 2 but for the gear unit of Fig. 5;

Figure 7 is a gear diagram of a fourth gear unit embodying the invention, this unit being similar to that of Fig. 3 but including an additional reverse gear assembly;

Figure 8 is a tabulation similar to that of Fig. 2 but for the gear unit of Fig. 7;

Figure 9 is gear diagram of a fifth form gear unit embodying the invention, this unit being provided with four gear trains and a reverse gear assembly on a reverse gear shaft; and

Figure 10 is a tabulation similar to that of Fig. 2 but for the gear unit of Fig. 9.

The spur change-speed gear units of Figs. 1, 3, 5, 7 and 9 are all provided with a double clutch assembly comprising a pair of first clutches A,B which are capabe of anit-phase actuation under load and are arranged to be driven from an input shaft 1, 10 of the gear unit through a housing of the double clutch assembly. The inner clutch plate carriers of the two clutches A, B are connected to respective driving shafts of the gear unit, these shafts being respectively constituted by a radially-inner shaft 2, 20 and and a coaxially arranged, hollow outer shaft 3, 30.

In addition to the double clutch assembly A/B, each gear unit to be described also comprises a take-off shaft 4, 40 coaxially disposed relative to the driving shaft 3, 20 and 3, 20; two lay shafts 5, 50 and 6, 60 disposed parallel, to but offset from, the driving shafts; a number of gear trains I to V; at least one reverse gear assembly; and a plurality of second clutches C to K selectively engageable to set up at least six forward and two reverse gear settings through the gear unit.

In each gear unit, the hollow driving shaft 3, 30 coming from the clutch B is connected to a driving gear wheel 31 which constitutes the drive member of a first one I of the gear trains.

Similarly the driving shaft 2, 20 coming from the clutch A is connected to a driving gear wheel 21 which constitutes the drive member of a second one II of the gear trains.

The gear units of Figs. 1, 3, 5 and 7 also have in common the provision of respective parts C_1, C_2 of a said second clutch C on the inner driving shaft 2 and the take-off shaft 4 whereby to permit the selective coupling of these shafts. Furthermore, in these units the first gear train I comprises, in addition to the driving gear wheel 31, a gear wheel 51 fast for rotation on a first one 5 of the lay shafts, and a second gear wheel 62 rotatably carried on the second lay shaft 6. Additionally, the second gear train II of each unit comprises, in addition to the driving gear wheel 21, a gear wheel 61 fast for rotation with the lay shaft 6 while a clutch F,F′ is so arranged on the second lay shaft 6 as to enable this shaft to be selectively coupled to the gear wheel 62.

This clutch F, F′ can be positioned either axially between the two gear trains I, II (Figs. 1 and 5) or on the side of the first gear train I nearest the input shaft 1 (Figs. 3 and 7). The clutch F, F′ enables the gear trains I and II to be interconnected so that torque can be transmitted from the first clutch A not only to the second lay shaft 6 direct, but also via the clutch F, F′ the gear wheel 62 and the driving gear wheel 31 to the first lay shaft 5.

Furthermore, the clutch F, F′ also enables torque to be transmitted from the clutch B not only to the first lay shaft 5 direct, but also the second lay shaft 6 and on to the shaft 2 via the gear wheel 62 and clutch F, F′.

The clutch F, F′ is important in connection with achieving both a low gear for steep gradients and a high gear for top speeds. Thus as will become apparent from the tabulations of Figs. 2, 4, 6 and 8, in the gear units of Figs. 1, 3, 5 and 7, a hill gear can be obtained via clutch A and clutch F, F′ in conjunction with a further clutch E, K, while a fast gear can be obtained via clutch B and clutch F, F′ in conjunction with the clutch C.

The gear units of Figs. 1, 3 and 7 further have in common a reverse gear assembly disposed principally on the first lay shaft 5 in the region of the second gear train II. This reverse gear assembly comprises a reverse gear wheel 54 rotatably mounted on the lay shaft 5, a reverse gear clutch J, selectively operable to render the gear wheel 54 fast for rotation with the shaft 5, and an intermediate wheel 55 operatively inter-posed between the gear wheel 54 and the driving gear wheel 21 on the radially inner driving shaft 2. For construction purposes, the reverse gear clutch F can be positioned between the gear trains II and III (see Figs. 3 and 7) rather than between the gear trains I and II as shown in Fig. 1, but this does not change the principle of operation of this assembly.

The positioning of the reverse gear assembly on one of the two lay shafts is especially important, as it enables respective reverse gears to be obtained via the two first clutches A and B.

In addition to the components already described, the Fig. 1 gear unit comprises third and fourth gear trains and further second clutches D, E, G.

The first lay shaft 5 rotatably carries gear wheels 52, 53 of the third and fourth gear trains respectively, these gear wheels 52, 53 being selectively connectable to the shaft 5 via respective ones of the second clutches D and E. These clutches D and E in fact constitute a double clutch assembly with a common member fast with the shaft 5. Two gear wheels 41 and 42, respectively of the third and fourth gear trains III and IV, are fast for rotation with the take-off shaft 4. The second lay shaft 6 rotatably carries a gear wheel 63 of the third train which can be selectively connected to this shaft 6 via the second clutch G.

The Fig. 3 gear unit has a fifth gear train V over and above the four gear trains of the Fig. 1 unit and, in addition, has a further gear wheel 64′ in its fourth gear train IV. This latter gear wheel is rotatably mounted on the second lay shaft 6 and is selectively couplable thereto by a clutch H which forms a double clutch assembly with the clutch G. The fifth gear train V comprises a gear wheel 43 fast for rotation with the take-off shaft 4, and a gear wheel 57 rotatably mounted on the lay shaft 5 and selectively couplable thereto by means of a clutch K.

The Fig. 5 gear unit is similar to that of Fig 1, with the difference that the reverse gear assembly is not carried on the first lay shaft 5 between the first and second gear trains I and II but on the second lay shaft 6, near the output end of the take-off shaft 4. More particularly, in the Fig. 5 unit the reverse gear assembly comprises a reverse gear wheel 64 rotatably carried on the shaft 6, a reverse gear clutch J′ operable by selectively connecting the lay shaft 6 with the reverse gear wheel 64, and an intermediate wheel 65 operatively interposed between the reverse gear wheel 64 and the gear wheel 42 for the purpose of drive reversal.

Fig. 7 illustrates a variant of the Fig. 3 gear unit in which a second reverse gear assembly, similar to that used with the Fig. 5 unit, is provided in order to enable further reverse gears to be obtained during shifting of the gear unit under load. This second reverse gear assembly comprises a reverse gear wheel 67 rotatably on the lay shaft 6, a reverse gear clutch J″ operable to selectively connect the shaft 6 with the reverse gear wheel 67, and an intermediate wheel 68 operatively interposed between the gear wheel 47 and the gear wheel 43 of the fifth gear train.

Of course, it is possible to modify the Fig. 7 gear unit by employing only this latter reverse gear assembly and dispensing with the use of the reverse gear assembly 54, 55 disposed in the region of the second gear train II.

In Fig. 9 gear unit differs substantially from the gear units of Figs. 1, 3, 5 and 7 in terms of the arrangement of its four gear trains I to IV. However, the basic idea of multiple use of clutches and gear wheels in a gear unit with a double clutch gear assembly actuatable under load and with two lay shafts is the same in the Fig. 9 unit as for the other units. A further common factor is the provision on the second lay shaft 60 of a clutch associted with the first gear train I, as well as the provision of a reverse gear assembly which in the Fig. 9 unit is positioned in the region of the gear trains I and II and includes a separate reverse gear shaft 7. To simplify Fig. 9, this reverse gear shaft 7 has been illustrated as being in the same plane as the other shafts, whereas in practice it is basically placed between the lay shafts 50, 60 and the driving shafts 20 and 30.

As previously mentioned, the clutch A of the double assembly is connected to the radially-inner driving shaft 2 carrying the driving gear wheel 21. This shaft 2 also carries one half F_1 of a clutch F, the other half F_2 of which is carried by the take-off shaft 40. The clutch B of the double clutch assembly is connected to the hollow driving shaft 30 carrying the gear wheel 31. Coaxial with the two driving shafts is the take-off shaft 40.

The take-off shaft 40 rotatably carries a double gear wheel component 44/45 which provides gear wheels 44, 45 of the third, and fourth gear trains respectively. This double gear wheel component is couplable with the take-off shaft 40 via a clutch J comprising clutch halves J_1, J_2 respectively fast for rotation with the component 44/45 and the shaft 40.

In addition to the gear wheel 44, the third gear train comprises a gear wheel 510 fast for rotation with the first lay shaft 50. The first lay shaft 50 also rotatably carries a gear wheel 520 of the first gear train I and a gear wheel 530 of the second gear train II, these gear wheels 520, 530 being selectively couplable to the shaft 50 by clutches D and E respectively.

In addition to the gear wheel 45 of the double gear wheel component, the fourth gear train comprises a gear wheel 610 fast for rotation with the second lay shaft 60. This lay shaft 60 also rotatably carries a gear wheel 620 of the first gear train I and gear wheel 630 of the second gear train II, these gear wheels 620, 630 being selectively couplable to the shaft 60 by clutches G and H respectively.

The reverse gear assembly of the Fig. 9 unit comprises a reverse gear shaft 7, a reverse gear wheel 71 fast for rotation with the shaft 7 and in mesh with the gear wheel 520, a further reverse gear wheel 72 rotatably carried on the shaft and in mesh with the driving gear wheel 21, and a reverse gear clutch C selectively operable to render the gear wheel 72 fast for rotation with the shaft 7.

Fig. 2, 4, 6, 8 and 10 respectively indicate for each of the gear units of Figs. 1, 3, 5, 7 and 9, which one of the two clutches A and B and which of the further clutches C to K must be engaged to set up each of the six or eight possible forward gear settings 1.G to 8.G and various reverse gear settings of each unit; the corresponding gearing ratio "i" through the unit is also shown for each possible gear setting. It can be readily seen that as each gear unit is shifted through its forward gear settings (and, in certain cases, its reverse gear settings), the two clutches A and B which are capable of actuation under load are engaged alternately. It can also be seen that for each forward gear setting, while drive is being transmitted through the gear unit via the drive line established by the engaged one of the two clutches A, B and engaged ones of the further clutches C to K, the further clutches not taking part in drive transmission can be selectively engaged and disengaged to set up the gear unit for the next required gear setting. This next required gear setting can then be engaged simply by reversing the state of engagement of the two clutches A and B of the double clutch assembly. Due to this arrangement, the further clutches C to K are not required to be engageable and disengageable under load.

It is to be noted that the gear settings given in the tabulations of Figs 2, 4, 6, 8 and 10 are not exhaustive and other settings are possible.

Various modifications to the described gear units are, of course, possible. Thus, for example, spur change speed gear units embodying the invention can be constructed with a larger number of useful gear settings.

It is furthermore possible to vary to some extent the arrangement of the gear wheels from that illustrated, for example, in Fig. 9 the reverse gear wheels 71, 72 can be respectively arranged to mesh with the driving gear wheel 31 and the gear wheel 630 carried on the second lay shaft 60.

CLAIMS

1. A spur change-speed gear unit shiftable under load and comprising an input shaft, a double-clutch assembly formed by two first clutches which are capable of anti-phase actuation under load and are connected on their input sides to said input shaft and on their output sides

respectively to a hollow driving shaft and a radially-inner driving shaft extending coaxially through said hollow shaft, a take-off shaft disposed in coaxial alignment with said driving shafts, two lay shafts disposed parallel to, but offset from, said driving shafts, a plurality of gear trains constituted by gear wheels carried on said shafts, and second clutches selectively engageable in different combincations to give various forward gear settings of the gear unit, the gear wheels and second clutches being arranged for multiple utilisation whereby to enable either additional useful forward and reverse gear settings to be obtained, or for the same number of gear settings, a reduction in the constructional complexity and therefore of the axial length of the gear unit.

2. A spur change-speed gear unit shiftable under load and comprising an input shaft, a double-clutch assembly formed by two first clutches which are capable of anti-phase actuation under load and are connected on their input sides to said input shaft and on their output sides respectively to a hollow driving shaft and a radially-inner driving shaft extending coaxially through said hollow shaft, a take-off shaft disposed in coaxial alignment with said driving shafts, first and second lay shafts disposed parallel to, but offset from, said driving shafts, a plurality of gear trains including a first gear train for transmitting drive between the hollow driving shaft and the first lay shaft and a second gear train for transmitting drive between the radially inner driving shaft and the second lay shaft, and second clutches selectively engageable in different combinations to give various gear settings of the gear unit, the arrangement of the gear unit being such that in at least one possible gear setting of the unit both lay shafts and/or components of both the first and second gear trains are simultaneously operative whereby to maximise utilisation of the gear unit components.

3. A spur change-speed gear unit according to Claim 2, including a reverse gear assembly comprising a reverse gear wheel rotatably carried on one said lay shaft, a reverse gear clutch selectively operable to render the reverse gear wheel fast for rotation with said one lay shaft, and an intermediate gear wheel operatively interposed between the reverse gear wheel and a gear-train gear wheel carried on the said take-off shaft.

4. A spur change-speed gear unit according to Claim 2, including a reverse gear assembly comprising a reverse gear wheel rotatably carried on one said lay shaft, a reverse gear clutch selectively operable to render the reverse gear wheel fast for rotation with said one lay shaft, and an intermediate gear wheel operatively interposed between the reverse gear wheel and a gear wheel fast for rotation with one of said driving shafts, this latter gear wheel forming part of that one of the first and second gear trains which is not arranged to transmit drive to the said one lay shaft.

5. A spur change-speed gear unit according to Claim 2, wherein one of said first and second gear trains as well as being arranged to transmit drive between a corresponding one of the driving shafts and the first or second lay shaft respectively, is further arranged to selectively transmit drive between said corresponding driving shaft and the other lay shaft and, to this end, includes an auxiliary gear wheel rotatably carried on said other lay shaft and in mesh with the gear train gear wheel carried on the said corresponding driving shaft, a said second clutch being arranged to selectively render said auxiliary gear wheel fast for rotation with said other lay shaft.

6. A spur change-speed gear unit according to Claim 5, wherein said unit comprises four gear trains arranged as follows:

—the hollow driving shaft non-rotatably carries a driving gear wheel of the first gear train,

—the radially inner driving shaft non-rotatably carries a driving gear wheel of the second gear train and is selectively couplable by means of a said second clutch to said take-off shaft;

—the take-off shaft non-rotatably carries a respective gear wheel from each of the third and fourth gear trains;

—said first lay shaft non-rotatably carries a gear wheel of the first gear train which is in mesh with the corresponding driving gear wheel carried on the hollow driving shaft, two further gear wheels respectively of the third and fourth gear trains being rotatably carried on the first lay shaft and meshing with the corresponding gear-train gear wheels on the take-off shaft, said further gear wheels being selectively couplable for rotation with the first lay shaft by respective second clutches,

—the second lay shaft non-rotatably mounts a gear wheel of the second gear train which is in mesh with the corresponding drivng gear wheel carried on the radially inner driving shaft, a further gear wheel of the third gear train being rotatably carried on the second lay shaft and being in mesh with the gear wheel of the third gear train carried on the take-off shaft, said further gear wheel being selectively couplable for rotation with the second lay shaft by means of a said second clutch; the first gear train being arranged to selectively transmit drive between the hollow driving shaft and the second lay shaft in accordance with Claim 5 by the mounting of said auxiliary gear wheel on the second lay shaft such that it is in mesh with the driving wheel of the first gear train.

7. A spur change-speed gear unit according to Claim 3 and Claim 6 in combination, wherein the reverse gear wheel of the reverse gear assembly is rotatably carried on the second lay shaft

and can be selectively rendered fast for rotation therewith by means of said reverse gear clutch, the intermediate gear wheel of the reverse gear assembly being operatively interposed between the reverse gear wheel and the gear wheel of the fourth gear train which is carried on the take-off shaft.

8. A spur change-speed gear unit according to Claim 4 and Claim 6 in combination, wherein the reverse gear wheel of the reverse gear assembly is rotatably carried on the first lay shaft and can be selectively rendered fast for rotation therewith by means of said reverse gear clutch, the intermediate gear wheel of the reverse gear assembly being operatively inteposed between the reverse gear wheel and the said driving gear wheel of the second gear train.

9. A spur change-speed gear unit according to Claim 6 or Claim 8, wherein the fourth gear train is provided with an additional gear wheel rotatably carried on the second lay shaft and in mesh with the fourth-train gear wheel which is carried by the take-off shaft, said additional gear wheel being selectively couplable for rotation with the second lay shaft by means of a said second clutch; the gear unit further comprising a fifth gear train formed by a first gear wheel fast for rotation on the take-off shaft and a cooperating second gear wheel rotatably carried by the first lay shaft and selectively couplable for rotation therewith by means of a said second clutch.

10. A spur change-speed gear unit according to Claim 3 and Claim 9 in combination, wherein the reverse gear wheel of the gear assembly of Claim 3 is rotatably carried on the second lay shaft and can be selectively renderded fast for rotation therewith by means of the reverse gear clutch of this reverse gear assembly, the corresponding intermediate gear wheel being operatively interposed between the reverse gear wheel and the said first gear wheel of the fifth gear train.

11. A spur change-speed gear unit according to Claim 2, wherein the first gear train comprises a driving gear wheel carried on the hollow driving shaft, and a cooperating gear wheel carried on the first lay shaft, and the second gear train comprises a driving gear wheel carried on the radially inner driving shaft and a cooperating gear wheel carried on the second lay shaft; the gear unit being further provided with a reverse gear assembly comprising first and second reverse gear wheels carried on a reverse gear shaft disposed parallel to, but offset from, said driving shafts, the reverse gear assembly being selectively operable to drivingly interconnect the said driving gear wheel of one of the first and second gear trains with the said cooperating gear wheel of the other of the second and first gear trains via said reverse gear wheels.

12. A spur change-speed gear unit according to Claim 2, comprising four gear trains arranged as follows:

—the hollow driving shaft non-rotatably carries a driving gear wheel of the first gear train,

—the radially inner driving shaft non-rotatably carries a driving gear wheel of the second gear train and is selectively couplable for rotation with the take-off shaft by means of a said second clutch,

—the take-off shaft rotatably carries a respective gear wheel from the third and fourth gear trains, these gear wheels being fast for rotation with each other and being selectively couplable for rotation with the take-off shaft by means of a said second clutch,

—the first lay shaft rotatably carries respective gear wheels from the first and second gear trains which gear wheels are in mesh with corresponding ones of the said driving gear wheels and are selectively couplable for rotation with the first lay shaft by means of respective second clutches, the first lay shaft further carrying a gear wheel of the third gear train which is fast for rotation with the first lay shaft and is in mesh with the third-train gear wheel carried on the take-off shaft, and

—the second lay shaft rotatably carries respective gear wheels from the first and second gear trains which gear wheels are in mesh with corresponding ones of said driving gear wheels and are selectively couplable for rotation with the second lay shaft by means of respective second clutches, the second lay shaft further carrying a gear wheel of the fourth gear train which is fast for rotation with the second lay shaft and is in mesh with the fourth-train gear wheel carried on the take-off shaft.

13. A spur change-speed gear unit according to Claims 11 and 12 in combination, wherein the first reverse gear wheel is fast for rotation with the reverse gear shaft and meshes with the first train gear wheel carried by the first lay shaft, the second reverse gear wheel being rotatably carried on the reverse gear shaft and being selectively couplable for rotation therewith by means of a said second clutch, the second reverse gear wheel being in mesh with the driving gear wheel of the second gear train.

14. A spur change-speed gear unit substantially as hereinbefore described with reference to Figs. 1 and 2, 3 and 4, 5 and 6, 7 and 8, or 9 and 10 of the accompanying drawings.

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